PB83-182386

National MOBILE2 Variable Estimates

Energy and Environmental Analysis, Inc.
Arlington, VA

Prepared for

Environmental Protection Agency
Ann Arbor, MI

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The purpose of this report is to develop national estimates of 12 MOBILE2 input variables for use in the MOBILE2 computer program and its supporting documentation. This report presents both the national estimates for each of these variables and explains the techniques used to derive them. In most cases, the estimates included in this report reflect national data inclusive of both urban and rural areas. Where only urban data was available for making national estimates, this is specifically noted in the report.

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VARIABLE ESTIMATES

EPA Contract No. 68-03-2888

Prepared for:

TEST AND EVALUATION BRANCH
EMISSION CONTROL TECHNOLOGY DIVISION
OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL
OFFICE OF AIR, NOISE AND RADIATION
U.S. ENVIRONMENTAL PROTECTION AGENCY
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1. INTRODUCTION

The purpose of this report is to describe work performed by EEA, Inc. for task order No. 5 of EPA Contract No. 68-03-2888. The objective of this task order was to develop national estimates of 12 MOBILE2 input variables for use in the MOBILE2 computer program and its supporting documentation. This report both presents the national estimates for each of these variables and explains the techniques used to derive them. In most cases, the estimates included in this report reflect national data inclusive of both urban and rural areas. Where only urban data were available for making national estimates, this is specifically noted in the report.

Table 1-1 shows the MOBILE2 input variables and vehicle types discussed in this report. The vehicle type abbreviations shown at the bottom of the table are those used throughout the report. The report is organized so that estimation techniques for each variable are presented in separate sections. The only exception to this is that variables 7-9 are combined in one section labeled "ambient conditions." Within each section, estimation techniques are presented separately for each vehicle type.

TABLE 1-1

MOBILE2 INPUT VARIABLES

Variables		Vehicle Type*
1.	Mileage accumulation by age	All
2.	Vehicle registrations by age	All
3.	Average trips/day	All
4.	Vehicle miles/day	All
5.	Total VMT fractions	All
6.	Fraction of vehicles with air conditioning by model year	All except MC, HDGV, and HDDV
7.	Air conditioning usage from ambient condition variables	**
8.	Average temperature	**
9.	Average humidity levels (grains of water/lb of dry air)	**
10.	Average percent VMT in cold/hot starts for catalyst and non-catalyst vehicles	All
11.	Fraction of trips/day with either extra load or trailer towing	All except MC, HDGV, and HDDV
12.	Speed	All

* LDGV: Light-Duty Gasoline-Powered Vehicles
LDDV: Light-Duty Diesel-Powered Vehicles
LDGT1: Light-Duty Gasoline-Powered Trucks (<6001 lbs GVW)
LDGT2: Light-Duty Gasoline-Powered Trucks (>6000 lbs and <8501 lbs GVW)
LDDT: Light-Duty Diesel-Powered Trucks (<8501 lbs GVW)
HDGV: Heavy-Duty Gasoline-Powered Vehicle (>8500 lbs GVW)
HDDV: Heavy-Duty Diesel-Powered Vehicle (>8500 lbs GVW)
MC: Motorcycles

**Independent of vehicle type

2. MILEAGE ACCUMULATION BY AGE

Estimates of national average mileage accumulation by age can be taken directly from Section 2 of Techniques for Estimating MOBILE2 Variables. The relevant tables from that section are shown in the following three pages.

Table 2-1 shows estimated annual miles traveled and mileage accumulation by age for light-duty vehicles. This table applies to both light-duty gasoline and diesel-powered vehicles. Table 2-2 presents mileage accumulation by age data for the five truck categories used in MOBILE2. Mileage accumulation by age information is presented in Table 2-3 for motorcycles.

TABLE 2-1

ESTIMATED ANNUAL MILES TRAVELED AND
MILEAGE ACCUMULATION BY AGE
FOR LIGHT-DUTY VEHICLES

NATIONAL AVERAGES

Age	Estimated Annual Miles	Accumulated Miles
1	14,436	14,436
2	13,903	28,339
3	13,371	41,710
4	12,838	54,548
5	12,306	66,854
6	11,773	78,627
7	11,240	89,867
8	10,708	100,575
9	10,176	110,751
10	9,643	120,394
11	9,110	129,504
12	8,577	138,081
13	8,045	146,126
14	7,513	153,639
15	6,980	160,619
16	6,447	167,066
17	5,927	172,993
18	5,382	178,375
19	4,850	183,225
20	4,317	187,542

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1980.

TABLE 2-2

MILEAGE ACCUMULATION BY AGE FOR TRUCK CATEGORIES

NATIONAL AVERAGES

Vehicle Age	LDGT1	LDGT2	HDGV	LDDT	HDDV
1	15,610	15,800	20,980	15,705	70,418
2	14,049	14,220	18,882	15,077	66,897
3	12,488	12,640	17,204	14,605	60,560
4	11,239	11,376	15,525	13,978	54,221
5	10,147	10,270	14,057	13,035	47,885
6	9,366	9,480	12,587	12,093	43,659
7	8,585	8,690	11,329	10,993	39,434
8	7,961	8,058	10,280	9,738	36,618
9	7,493	7,584	9,441	9,266	34,504
10	7,025	7,110	8,602	7,381	33,096
11	6,556	6,636	7,973	6,753	32,392
12	6,244	6,320	7,343	6,125	31,689
13	5,932	6,004	6,713	5,491	30,953
14	5,463	5,510	6,294	5,031	29,606
15	5,151	5,234	5,875	4,555	27,463
16	4,996	5,056	5,454	4,240	24,646
17	4,683	4,740	5,245	3,769	20,422
18	4,370	4,424	5,036	3,141	17,604
19	4,371	4,424	5,034	3,141	17,605
20	4,371	4,424	5,034	3,141	17,605

Source: Jambekar and Johnson, 1977.

TABLE 2-3

NATIONAL AVERAGE MILES PER YEAR BY AGE AND MILEAGE ACCUMULATION BY AGE FOR MOTORCYCLES

Age	Average Miles* Per Year	Average Mileage Accumulation
1	4067	4067
2	2845	6912
3	2072	8984
4	1569	10553
5	1180	11733
6	777	12510
7	630	13140
8	387	13527
9	243	13770
10	162	13932
11	162	14094
12	162	14256
13	162	14418

Mean number of months per year 7
Median number of months per year 7

---

* Weighted by the mix of on-road and dual purpose motorcycles registered in 1978.

Source: Personal Communication with Pam Amette, Motorcycle Industry Council, Inc., and the 1979 Motorcycle Statistical Annual

3. VEHICLE REGISTRATIONS BY AGE

Estimates of national vehicle registrations by age for the eight MOBILE2 vehicle type categories are presented in this section. Much of the data used in the tables in this section are taken directly from Section 3 of Techniques For Estimating MOBILE2 Variables. National light-duty vehicle registrations by model year are shown in Table 3-1. Both light-duty gasoline and diesel-powered vehicle registrations are accounted for in these totals. LDGV and LDDV registrations are estimated using the fleet sales fractions listed in Table 3-2. Tables 3-3 and 3-4 show how these sales fractions are used to estimate national LDGV and LDDV registrations by model year in 1978.

Tables 3-5, 3-6 and 3-7 show how sales and scrappage rate information from Section 3 of the Techniques report can be used to estimate registrations by model year for LDGT1, LDGT2, and LDDT, respectively. In order to apply the diesel and gasoline sales fractions in Table 3-2 (which are used in MOBILE2) to estimate LDGT1 and LDDT registrations, the estimated registrations by model year in Tables 3-5 and 3-7 are summed. Table 3-8 lists these totals. Tables 3-9 and 3-10 then show how the Table 3-2 dieselization rates are used to estimate national LDGT1 and LDDT registrations by age.

Table 3-11 shows the calculation of national vehicle registration fractions for heavy-duty gasoline-powered trucks. Heavy-duty diesel-powered truck registrations are calculated in a similar manner as shown in Table 3-12. Motorcycle registration fractions by age are listed in Table 3-13.

TABLE 3-1

LIGHT-DUTY VEHICLE REGISTRATIONS BY MODEL YEAR MIX

NATIONAL TOTALS IN 1978

Model Year Mix	Estimated Vehicle Registrations	Percentage of Total LDV Registrations
1	7,426,000	.0721
2	10,382,000	.1009
3	9,483,000	.0921
4	7,291,000	.0708
5	9,431,000	.0916
6	10,559,000	.1026
7	9,140,000	.0888
8	7,326,000	.0712
9	6,784,000	.0659
10	6,087,000	.0591
11	4,917,000	.0478
12	3,589,000	.0349
13	3,093,000	.0300
14	2,369,000	.0230
15	1,545,000	.0150
16	1,021,000	.0099
17	571,000	.0055
18	256,000	.0025
19	180,000	.0017
20	1,489,000	.0145
TOTAL	102,939,000	

SOURCE: MVMA, Motor Vehicle Facts and Figures 1979.

TABLE 3-2

FLEET SALES FRACTIONS* FOR 49-STATE
LIGHT-DUTY VEHICLES AND LIGHT-DUTY TRUCKS

Model Years	LDGV	LDDV	LDGT1	LDDT
PRE-1975	1.000	0.0	1.000	0.0
1975	.998	.002	1.000	0.0
1976	.997	.003	1.000	0.0
1977	.995	.005	1.000	0.0
1978	.991	.009	.991	.009
1979	.972	.028	.972	.028
1980	.966	.034	.966	.034
1981	.953	.047	.953	.047
1982	.925	.075	.925	.075
1983	.911	.089	.911	.089
1984	.905	.095	.905	.095
1985	.886	.114	.886	.114
1986	.862	.138	.862	.138
1987	.835	.165	.835	.165
1988	.824	.176	.824	.176
1989	.813	.187	.813	.187
1990	.803	.197	.803	.197
1991+	.800	.200	.800	.200

* The estimated fraction of the light-duty vehicle (truck) fleet which is diesel-powered is taken from Murrell et al. (1980) for 1975-1980 model years and U.S. EPA (1979) for 1981-1991 model years.

TABLE 3-3

LIGHT-DUTY GASOLINE-POWERED VEHICLES
ESTIMATED VEHICLE REGISTRATIONS
NATIONAL TOTALS IN 1978

Model Year Mix (Age)	LDGV & LDDV Estimated Vehicle Registrations	Fleet Sales* Fraction for LDGV	Estimated LDGV Registrations	Registration Fractions
1	7,426,000	.991	7,359,166	.072
2	10,382,000	.995	10,330,090	.101
3	9,483,000	.997	9,454,551	.092
4	7,291,000	.998	7,276,418	.071
5	9,431,000	1.000	9,431,000	.092
6	10,559,000	1.000	10,559,000	.103
7	9,140,000	1.000	9,140,000	.089
8	7,326,000	1.000	7,326,000	.071
9	6,784,000	1.000	6,784,000	.066
10	6,087,000	1.000	6,087,000	.059
11	4,917,000	1.000	4,917,000	.048
12	3,589,000	1.000	3,589,000	.035
13	3,093,000	1.000	3,093,000	.030
14	2,369,000	1.000	2,369,000	.023
15	1,545,000	1.000	1,545,000	.015
16	1,021,000	1.000	1,021,000	.010
17	571,000	1.000	571,000	.006
18	256,000	1.000	256,000	.002
19	180,000	1.000	180.000	.002
20+	1,489,000	1.000	1,489,000	.014
	102,939,000		102,780,000	

* The estimated fraction of the light-duty vehicle fleet which is diesel-powered is taken from Murrell et al. (1980).

TABLE 3-4

LIGHT-DUTY DIESEL-POWERED VEHICLES
ESTIMATED VEHICLE REGISTRATIONS
NATIONAL TOTALS IN 1978

Model Year Mix (Age)	LDGV & LDDV Estimated Vehicle Registrations	Fleet Sales* Fraction for LDDV	Estimated LDDV Registrations	Registration Fractions
1	7,426,000	0.009	66,834	.413
2	10,382,000	.005	51,910	.321
3	9,483,000	.003	28,449	.176
4	7,291,000	.002	14,582	.090
5	9,431,000	0.0		
6	10,559,000	0.0		
7	9,140,000	0.0		
8	7,326,000	0.0		
9	6,784,000	0.0		
10	6,087,000	0.0		
11	4,917,000	0.0		
12	3,589,000	0.0		
13	3,093,000	0.0		
14	2,369,000	0.0		
15	1,545,000	0.0		
16	1,021,000	0.0		
17	571,000	0.0		
18	256,000	0.0		
19	180,000	0.0		
20+	1,489,000	0.0		
			161,775	

* The estimated fraction of the light-duty vehicle fleet which is diesel-powered is taken from Murrell et al. (1980).

TABLE 3-5

CALCULATION OF NATIONAL VEHICLE REGISTRATIONS
FOR LIGHT-DUTY GASOLINE TRUCKS (0-6000 LBS. GVW)

Model Year	Vehicle Age	Sales* 0-6000 lbs.	1-SR** 10,000 lbs.	Estimated Registrations
1978	1	1,211,899	1.00	1,211,899
1977	2	1,251,449	.97	1,213,906
1976	3	1,181,906	.93	1,099,173
1975	4	897,292	.88	789,617
1974	5	1,409,586	.83	1,169,956
1973	6	1,639,663	.78	1,278,937
1972	7	1,339,226	.73	977,635
1971	8	1,133,911	.68	771,059
1970	9	895,238	.63	564,000
1969	10	1,052,057	.59	620,714
1968	11	1,069,389	.55	588,164
1967	12	836,429	.51	426,579
1966	13	957,168	.47	449,869
1965	14	987,503	.43	424,626
1964	15	839,808	.40	335,923
1963	16	765,114	.36	275,441
1962	17	610,600	.32	195,392
1961	18	524,135	.28	146,758
1960	19	534,431	.25	133,608
1959	20+	461,885	.21	96,996
1958		346,209	.18	62,318
				12,832,570

* From Table 3-10 of Techniques For Estimating MOBILE2 Variables, 1980.

** From Table 3-7 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 3-6

CALCULATION OF NATIONAL VEHICLE REGISTRATION FRACTIONS
FOR LIGHT-DUTY GASOLINE TRUCKS (6000-8500 LBS. GVW)

Model Year	Vehicle Age	Sales* 6000-8500 lbs.	1-SR** 10,000 lbs.	Estimated Registrations	Registration Fractions
1978	1	1,389,944	1.00	1,389,944	.245
1977	2	1,211,845	.97	1,175,490	.207
1976	3	947,790	.93	881,445	.155
1975	4	625,731	.88	550,643	.097
1974	5	391,225	.83	324,717	.057
1973	6	407,337	.78	317,723	.056
1972	7	303,986	.73	221,910	.039
1971	8	247,485	.68	168,290	.030
1970	9	208,414	.63	131,301	.023
1969	10	192,945	.59	113,838	.020
1968	11	178,527	.55	98,190	.017
1967	12	124,803	.51	63,650	.011
1966	13	117,075	.47	55,025	.010
1965	14	105,622	.43	45,417	.008
1964	15	76,305	.40	30,522	.005
1963	16	86,007	.36	30,963	.005
1962	17	79,134	.32	25,323	.004
1961	18	57,597	.28	16,127	.003
1960	19	58,283	.25	14,571	.003
1959	20+	65,562	.21	13,768	.004
1958		47,694	.18	8,585	
				5,677,442	

* From Table 3-10 of Techniques For Estimating MOBILE2 Variables, 1980.

** From Table 3-7 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 3-7

CALCULATION OF NATIONAL VEHICLE REGISTRATIONS
FOR LIGHT-DUTY DIESEL TRUCKS (0-8500 LBS. GVW)

Model Year	Vehicle Age	Sales* <8500 lbs.	1-SR** <10,000 lbs.	Estimated Registrations
1978	1	34,751	1.00	34,751
1977	2	2,924	.97	2,836
1976	3	1,303	.93	1,212
1975	4	1	.88	1
1974	5	0	.83	0
1973	6	0	.78	0
1972	7	0	.73	0
1971	8	70	.68	48
1970	9	233	.63	147
1969	10	445	.59	263
1968	11	714	.55	393
1967	12	801	.51	409
1966	13	431	.47	203
1965	14	494	.43	212
1964	15	994	.40	398
1963	16	162	.36	58
1962	17	75	.32	24
1961	18	9	.28	3
1960	19	0	.25	0
1959	20+	0	.21	0
				40,958

* From Table 3-11 of Techniques For Estimating MOBILE2 Variables, 1980.

** From Table 3-7 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 3-8

LIGHT-DUTY GASOLINE TRUCKS (0-6000 LBS. GVW) AND
LIGHT-DUTY DIESEL TRUCKS (0-8500 LBS. GVW)
COMBINED VEHICLE REGISTRATIONS

NATIONAL TOTALS IN 1978

Model Year Mix (Age)	Estimated Vehicle Registrations
1	1,246,650
2	1,216,742
3	1,100,385
4	789,618
5	1,169,956
6	1,278,937
7	977,635
8	771,107
9	564,147
10	620,977
11	588,557
12	426,988
13	450,072
14	424,838
15	336,321
16	275,499
17	195,416
18	146,761
19	133,608
20+	159,314

TABLE 3-9

LIGHT-DUTY GASOLINE TRUCKS (0-6000 LBS. GVW)
ESTIMATED VEHICLE REGISTRATIONS

NATIONAL TOTALS IN 1978

Model Year Mix (Age)	LDGT & LDDT Estimated Vehicle Registrations	Fleet Sales* Fraction for LDGT1	Estimated LDGT1 Registrations	Registrations Fractions
1	1,246,650	0.991	1,235,430	.096
2	1,216,742	1.000	1,216,742	.095
3	1,100,385	1.000	1,100,385	.086
4	789,618	1.000	789,618	.061
5	1,169,956	1.000	1,169,956	.091
6	1,278,937	1.000	1,278,937	.099
7	977,635	1.000	977,635	.076
8	771,107	1.000	771,107	.060
9	564,147	1.000	564,147	.044
10	620,977	1.000	620,977	.048
11	588,557	1.000	588,557	.046
12	426,988	1.000	426,988	.033
13	450,072	1.000	450,072	.035
14	424,838	1.000	424,838	.033
15	336,321	1.000	336,321	.026
16	275,499	1.000	275,499	.021
17	195,416	1.000	195,416	.015
18	146,761	1.000	146,761	.011
19	133,608	1.000	133,608	.010
20+	159,314	1.000	159,314	.012
			12,862,308	

* The estimated fraction of the light-duty truck fleet which is diesel-powered is taken from Murrell et al. (1980).

TABLE 3-10

LIGHT-DUTY DIESEL TRUCKS (0-8500 LBS. GVW)
ESTIMATED VEHICLE REGISTRATIONS

NATIONAL TOTALS IN 1978

Model Year Mix (Age)	LDGT1 & LDDT Estimated Vehicle Registrations	Fleet Sales* Fraction for LDDT	Estimated LDDT Registrations	Registration Fractions
1	1,246,650	0.009	11,220	1.000
2	1,216,742	0.0		
3	1,100,385	0.0		
4	789,618	0.0		
5	1,169,956	0.0		
6	1,278,937	0.0		
7	977,635	0.0		
8	771,107	0.0		
9	564,147	0.0		
10	620,977	0.0		
11	588,557	0.0		
12	426,988	0.0		
13	450,072	0.0		
14	424,838	0.0		
15	336,321	0.0		
16	275,499	0.0		
17	195,416	0.0		
18	146,761	0.0		
19	133,608	0.0		
20+	159,314	0.0		

* The estimated fraction of the light-duty truck fleet which is diesel-powered is taken from Murrell et al. (1980).

TABLE 3-11

CALCULATION OF NATIONAL VEHICLE REGISTRATION FRACTIONS
FOR HEAVY-DUTY GASOLINE TRUCKS (8500 LBS GVW)

Model Year	Sales* 8501-10,000 lb	(1-Scrappage)** Rate <10,000 lb	Estimated Registrations (8501-10,000 lb)	Sales* <10,000 lb	(1-Scrappage)** Rate >10,000 lb	Total Estimated Registrations (>10,000 lb)	Estimated Registrations (>8500 lb)	Registration Fractions
1978	388,781	1.00	388,781	205,109	1.00	205,109	593,890	.128
1977	368,078	.97	357,036	182,089	.95	172,985	530,021	.114
1976	318,230	.93	295,954	178,955	.88	157,480	453,434	.097
1975	227,578	.88	200,269	179,551	.79	141,845	342,114	.074
1974	269,087	.83	223,342	255,026	.69	175,968	399,310	.086
1973	305,873	.78	238,581	281,781	.61	171,886	410,467	.088
1972	245,537	.73	179,242	275,994	.54	149,037	328,279	.071
1971	206,415	.68	140,362	225,009	.48	108,004	248,366	.053
1970	164,913	.63	103,895	205,303	.43	88,280	192,175	.041
1969	186,035	.59	109,761	248,437	.38	94,406	204,167	.044
1968	186,470	.55	102,559	247,282	.33	81,603	184,162	.040
1967	143,632	.51	73,252	238,774	.29	69,244	142,496	.031
1966	160,519	.47	75,444	254,381	.25	63,595	139,039	.030
1965	163,340	.43	70,236	257,012	.20	51,402	121,638	.026
1964	136,891	.40	54,756	241,490	.17	41,053	95,809	.021
1963	127,189	.36	45,788	261,227	.14	36,572	82,360	.018
1962	103,064	.32	32,980	246,729	.11	27,140	60,120	.013
1961	86,926	.28	24,339	231,050	.08	18,484	42,823	.009
1960	88,566	.25	22,142	265,006	.06	15,900	38,042	.008
1959	78,814	.21	16,551	301,055	.04	12,042	28,593	.006
1958	58,859	.18	10,595	220,456	.03	6,614	17,209	.004
							4,654,514	1.002

* From Table 3-10 of Techniques For Estimating MOBILE2 Variables, 1980.

** From Table 3-7 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 3-12

CALCULATION OF NATIONAL VEHICLE REGISTRATION FRACTIONS
FOR HEAVY-DUTY DIESEL TRUCKS (8500 LBS. GVW)

Model Year	Vehicle Age	Sales* 8501-10,000 lb.	1-SR** <10,000 lb.	Estimated Registrations (8501-10,000 lb.)	Sales* >10,000 lb.	1-SR** >10,000 lb.	Estimated Registrations (>10,000 lb.)	Total Estimated Registrations (>8500 lb.)	Registration Fractions
1978	1	840	1.00	840	184,324	1.00	184,324	185,164	.177
1977	2	437	.97	424	162,198	.91	147,600	148,024	.142
1976	3	195	.93	181	105,718	.84	88,803	88,984	.085
1975	4	0	.88	0	72,604	.77	55,905	55,905	.054
1974	5	0	.83	0	144,702	.71	102,738	102,738	.098
1973	6	0	.78	0	152,159	.64	97,382	97,382	.093
1972	7	0	.73	0	129,628	.58	75,184	75,184	.072
1971	8	11	.68	7	101,407	.53	53,746	53,753	.051
1970	9	35	.63	22	91,533	.48	43,936	43,958	.042
1969	10	67	.59	40	101,191	.43	43,512	43,552	.042
1968	11	107	.55	59	82,602	.39	32,215	32,274	.031
1967	12	120	.51	61	69,879	.35	24,458	24,519	.023
1966	13	64	.47	30	85,054	.31	26,367	26,397	.025
1965	14	74	.43	32	71,789	.28	20,101	20,133	.019
1964	15	148	.40	59	56,037	.24	13,449	13,508	.013
1963	16	24	.36	9	47,025	.21	9,875	9,884	.009
1962	17	11	.32	4	38,378	.19	7,292	7,296	.007
1961	18	0	.28	0	24,931	.16	3,989	3,989	.004
1960	19	0	.25	0	28,186	.14	3,946	3,946	.004
1959	20+	0	.21	0	32,741	.11	3,602	3,602	.007
1958					22,884	.09	2,060	2,060	
1957					21,607	.07	1,512	1,512	
								1,043,764	

* From Table 3-11 of Techniques For Estimating MOBILE2 Variables, 1980.

** From Table 3-7 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 3-13

MOTORCYCLE REGISTRATIONS -- PERCENTAGE BY AGE

NATIONAL AVERAGE

Motorcycle Age (years)	Fraction of* Total Registrations
1	.133
2	.145
3	.138
4	.116
5	.123
6	.114
7	.069
8	.044
9	.024
10	.009
11+	.085
	1.000

*Based on the estimated population in use in 1978.

Source: Motorcycle Industry Council, Inc., 1979

4. AVERAGE TRIPS PER DAY

National average estimates of the number of trips per day per vehicle can be determined from Section 7 of Techniques for Estimating MOBILE2 Variables. Estimates are presented below for each vehicle type.

Light-Duty Vehicles

Table 7-1 in the Techniques report shows the trip rate per household by location and population. The average trip rate per household is 4.3 for unincorporated areas and 3.6 for incorporated areas. Weighting these two trip rates by the respective U.S. population in 1970 (8.85% of the 1970 population lived in unincorporated places, the remainder in incorporated places), gives an average U.S. trip rate per household of 3.66 per day. This should be divided by the average number of cars per household to determine the average number of trips per day per vehicle. According to the NPTS, the average number of cars per household is 1.2. Therefore, the average number of trips per day per vehicle is 3.05. This number should apply to both light-duty gasoline and diesel-powered vehicles.

Light-Duty Trucks

Although no specific data on light-duty truck travel are available from the 1972 NPTS, it is assumed here that the 3.05 trips per day estimate for light-duty vehicles also applies to light-duty trucks. All light-duty truck classes (LDGT1, LDGT2, LDDT) are assumed to have the same tripmaking patterns.

Heavy-Duty Vehicles

Using New York and Los Angeles data (France, 1978) from an EPA Technical Report, the average number of trips/day for heavy-duty vehicles is 6.88 for HDGV and 6.65 for HDDV. (See Table 7-6 in the Techniques report).

Motorcycles

The national average motorcycle trips per day are estimated using Table 7-7 in the Techniques report. The relevant portion of that table is shown below.

Motorcycle Trip Purpose	Percentage of Total Registered Motorcycles Used For This Purpose	Median Number of One Way Trips/Day	Trips/Day Per Trip Purpose
Commuting:			
Work	36	0.7	.25
School	10	0.6	.06
Non-Commuting:	100	1.04	1.04
TOTAL			1.35

Therefore, the average number of trips per day per registered motorcycle is 1.35.

5. VEHICLE MILES PER DAY

National average estimates of vehicle miles traveled per day by vehicle type are shown in Table 5-1. The calculations used to derive these estimates are illustrated in Tables 5-2 through 5-8, one for each vehicle type. Miles per day estimates for all vehicle categories use estimated nationwide registrations in 1978 and average mileage accumulation by age information to compute an average VMT per year number. After this number is converted to VMT per day, it is divided by the total number of registered vehicles in 1978 to derive a per vehicle estimate. All vehicle types are assumed to travel 365 days per year except motorcycles. Motorcycles are assumed to drive 7 months or 210 days per year. The calculation of average miles per day by vehicle type is summarized in Table 5-9 for all vehicle types except light-duty vehicles.

TABLE 5-1

NATIONAL AVERAGE

MILES TRAVELED PER DAY BY VEHICLE TYPE

Vehicle Type	Miles/Day
LDGV	31.1
LDDV	31.1
LDGT 1	26.3
LDGT 2	33.8
LDDT	29.8
HDGV	36.7
HDDV	138.1
MC	8.3

TABLE 5-2

LDGV AND LDDV COMBINED
CALCULATION OF NATIONAL AVERAGE ANNUAL MILES DRIVEN

Model Year	Estimated* Registrations ($\times 10^3$)	Annual Mileage**	VMT by Model Year ($\times 10^8$)
1978	7,426	14,436	1,072.0
1977	10,382	13,903	1,443.4
1976	9,483	13,371	1,268.0
1975	7,291	12,838	936.0
1974	9,431	12,306	1,160.6
1973	10,559	11,773	1,243.1
1972	9,140	11,240	1,027.3
1971	7,326	10,708	784.5
1970	6,784	10,176	690.3
1969	6,087	9,643	587.0
1968	4,917	9,110	447.9
1967	3,589	8,577	307.8
1966	3,093	8,045	248.8
1965	2,369	7,513	178.0
1964	1,545	6,980	107.8
1963	1,021	6,447	65.8
1962	571	5,927	33,8
1961	256	5,382	13.8
1960	180	4,850	8.7
1959	1,489	4,317	64.3
	102,939		11,688.9

* From Table 3-2 of Techniques For Estimating MOBILE2 Variables.

** From Table 2-1 of Techniques For Estimating MOBILE2 Variables.

TABLE 5-3

LIGHT-DUTY GASOLINE TRUCKS (0-6000 LBS. GVW)
CALCULATION OF NATIONAL AVERAGE ANNUAL MILES DRIVEN

Model Year	LDGT1 + LDDT Estimated Registrations (From Table 3-8)	Annual Mileage*	VMT by Model Year ($\times 10^8$)
1978	1,246,650	15,610	194.6
1977	1,216,742	14,049	170.9
1976	1,100,385	12,488	137.4
1975	789,618	11,239	88.7
1974	1,169,956	10,147	118.7
1973	1,278,937	9,366	119.8
1972	977,635	8,585	83.9
1971	771,107	7,961	61.4
1970	564,147	7,493	42.3
1969	620,977	7,025	43.6
1968	588,557	6,556	38.6
1967	426,988	6,244	26.7
1966	450,072	5,932	26.7
1965	424,838	5,463	23.2
1964	336,321	5,151	17.3
1963	275,499	4,996	13.8
1962	195,416	4,683	9.2
1961	146,761	4,370	6.4
1960	133,608	4,371	5.8
1959	96,996	4,371	4.2
1959	62,318	4,371	2.7
	12,873,528		1,235.9

* From Table 2-4 of Techniques For Estimating MOBILE2 Variables.

TABLE 5-4

LIGHT-DUTY DIESEL TRUCKS (0-8500 LBS. GVW)
CALCULATION OF NATIONAL AVERAGE ANNUAL MILES DRIVEN

Model Year	LDGT1 + LDDT Estimated Registrations (From Table 3-8)	Annual Mileage*	VMT by Model Year ($\times 10^8$)
1978	1,246,650	15,705	195.8
1977	1,216,742	15,077	183.4
1976	1,100,385	14,605	160.7
1975	789,618	13,978	110.4
1974	1,169,956	13,035	152.5
1973	1,278,937	12,093	154.7
1972	977,635	10,993	107.5
1971	771,107	9,738	75.1
1970	564,147	9,266	44.3
1969	620,977	7,381	41.9
1968	588,557	6,753	36.0
1967	426,988	6,125	23.5
1966	450,072	5,497	22.6
1965	424,838	5,031	19.4
1964	336,321	4,555	14.3
1963	275,499	4,240	10.4
1962	195,416	3,769	6.1
1961	146,761	3,141	4.6
1960	133,608	3,141	4.2
1959	96,996	3,141	3.0
1958	62,318	3,141	2.0
	12,873,528		1,398.4

* From Table 2-4 of Techniques For Estimating MOBILE2 Variables.

TABLE 5-5

LIGHT-DUTY GASOLINE TRUCKS (6001-8500 LBS. GVW)
CALCULATION OF NATIONAL AVERAGE ANNUAL MILES DRIVEN

Model Year	Estimated Registrations	Annual Mileage	VMT by Model Year ($x10^8$)
1978	1,389,944	15,800	219.61
1977	1,175,490	14,220	167.15
1976	881,445	12,640	111.41
1975	550,643	11,376	62.64
1974	324,717	10,270	33.35
1973	317,723	9,480	30.12
1972	221,910	8,690	19.28
1971	168,290	8,058	13.56
1970	131,301	7,584	9.96
1969	113,838	7,110	8.09
1968	98,190	6,636	6.52
1967	63,650	6,320	4.02
1966	55,025	6,004	3.30
1965	45,417	5,510	2.50
1964	30,522	5,234	1.60
1963	30,963	5,056	1.57
1962	25,323	4,740	1.20
1961	16,127	4,424	0.71
1960	14,571	4,424	0.64
1959	13,768	4,424	0.61
1958	8,585	4,424	0.38
TOTAL LDGT2 VMT per year			698.22

TABLE 5-6

HEAVY DUTY GASOLINE VEHICLES
CALCULATION OF NATIONAL AVERAGE ANNUAL MILES DRIVEN

Calendar Year	Estimated Registrations	Annual Mileage*	VMT by Model Yr ($\times 10^9$)
1978	593,890	20,980	12.46
1977	530,021	18,882	10.01
1976	453,434	17,204	7.80
1975	342,114	15,525	5.31
1974	399,310	14,057	5.61
1973	410,467	12,587	5.17
1972	328,279	11,329	3.72
1971	248,366	10,280	2.55
1970	192,175	9,441	1.81
1969	204,167	8,602	1.76
1968	184,162	7,973	1.47
1967	142,496	7,343	1.05
1966	139,039	6,713	.93
1965	121,638	6,294	.77
1964	95,809	5,875	.56
1963	82,360	5,454	.45
1962	60,120	5,245	.32
1961	42,823	5,036	.22
1960	38,042	5,034	.19
1959	28,593	5,034	.14
1958	17,209	5,034	.09
Total Heavy Duty Gasoline Vehicle VMT per Year			62.39

* From Table 2-4 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 5-7

HEAVY-DUTY DIESEL VEHICLES

CALCULATION OF NATIONAL AVERAGE ANNUAL MILES DRIVEN

Calendar Year	Estimated Registrations	Annual Mileage*	VMT x 10^9 by Model Year
1978	185,164	70,418	13.039
1977	148,024	66,897	9.902
1976	88,984	60,560	5.389
1975	55,905	54,221	3.031
1974	102,738	47,885	4.920
1973	97,382	43,659	4.252
1972	75,184	39,434	2.965
1971	53,753	36,618	1.968
1970	43,958	34,504	1.517
1969	43,552	33,096	1.441
1968	32,274	32,392	1.045
1967	24,519	31,689	0.777
1966	26,397	30,953	0.817
1965	20,133	29,606	0.596
1964	13,508	27,463	0.371
1963	9,884	24,646	0.244
1962	7,296	20,422	0.149
1961	3,989	17,605	0.070
1960	3,946	17,604	0.069
1959	3,602	17,604	0.063
Total Heavy-Duty Diesel Vehicle VMT per Year			52.625

* From Table 2-4 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 5-8

MOTORCYCLES

CALCULATION OF AVERAGE ANNUAL MILES DRIVEN

Year Sold New	Estimated* Population In Use ($x10^3$)	Annual Mileage**	Estimated Total Annual VMT ($x10^8$)
1978	975	4,067	39.7
1977	1,058	2,845	30.1
1976	1,008	2,072	20.9
1975	846	1,569	13.3
1974	900	1,180	10.6
1973	836	777	6.5
1972	503	630	3.2
1971	322	387	1.2
1970	172	243	0.4
1969	67	162	0.1
1968+	618	162	1.0
	7,305		127.0

*SOURCE: Motorcycle Industry Council, Inc. 1979.

** From Table 2-4 of Techniques For Estimating MOBILE2 Variables, 1980.

TABLE 5-9

CALCULATION OF AVERAGE MILES PER DAY BY VEHICLE TYPE

Vehicle Type	VMT per year ($x10^6$)	VMT per day ($x10^6$)	Estimated Nationwide Registrations	Average Miles Per Day
LDGV	1,168,890	3,202.44	102,939,000	31.1
LDDV				31.1
LDGT1	123,590	338.60	12,873,528*	26.3
LDGT2	69,822	191.29	5,667,442	33.8
LDDT	139,840	383.12	12,873,528*	29.8
HDGV	62,390	170.93	4,654,514	36.7
HDDV	52,625	144.18	1,043,764	138.1
MC	12,700	60.48	7,305,000	8.3

* LDGT1 and LDDT registrations combined.

6. VEHICLE MILES TRAVELED

Estimates of nationwide vehicle miles traveled are taken from the MVMA Motor Vehicle Facts and Figures 1979 annual report. These estimates represent motor vehicle travel in the United States in 1977. The VMT estimates applicable to apportioning rural and urban travel to the MOBILE2 categories are presented in Table 6-1. Because the MVMA vehicle categories do not match those used in MOBILE2, the VMT estimates from MVMA were weighted by the estimated nationwide registrations to apportion them to the MOBILE2 categories. Estimated nationwide registrations are shown in Table 6-2.

In order to apportion the MVMA VMT estimates to the MOBILE2 vehicle categories, the following assumptions were made:

- Passenger cars in the MVMA terminology are all light-duty vehicles.
- Motorcycles in the MVMA report match the MOBILE2 category.
- All commercial buses are diesel-powered and all school buses are gasoline powered.
- All HDDV's that are not commercial buses are combination trucks.
- Single unit truck VMT is apportioned between LDGT1, LDGT2, LDDT, and HDGV in proportion to their estimated registration.

Heavy-duty diesel vehicle VMT is estimated as follows:

$$\text{HDDV VMT} = \text{Commercial Bus VMT} + \text{Combinations VMT} \times \left[\frac{\text{HDDV Registrations} - \text{Commercial Bus Registrations}}{\text{Combinations Registration}}\right] \quad (6\text{-}1)$$

$$= 2{,}937 + 63{,}465 \left[\frac{1{,}043{,}764 - 97{,}900}{1{,}264{,}100}\right]$$

$$= 50{,}425 \text{ annual miles}$$

TABLE 6-1

MOTOR VEHICLE TRAVEL IN THE UNITED STATES, 1977

	Passenger Cars	Motorcycles	Commercial Buses	School Buses	Single Unit Trucks	Combinations
Motor Vehicle Travel (Miles x 10^6)	1,118,649	22,566	2,957	2,950	266,000	63,465
Total Rural and Urban						
Percentage of Total Annual Travel	75.76%	1.53	0.20	0.20	18.01	4.30
Number of Vehicles Registered (x 10^3)	113,696.1	5,014.6	97.9	393.8	28,298.4	1,264.1

Source: MVMA, 1979

TABLE 6-2

ESTIMATED NATIONWIDE REGISTRATIONS BY VEHICLE TYPE

Vehicle Type	Estimated Nationwide Registrations*
LDGV	102,711,775
LDDV	227,225
LDGT1	12,832,570
LDGT2	5,677,442
LDDT	40,958
HDGV	4,654,514
HDDV	1,043,764
MC	7,305,000
Total	127,642,248

*Based on 1978 calendar year registrations.

The HDGV portion of the combinations VMT is estimated using equation (6-2):

HDGV VMT = Combinations VMT - HDDV VMT
= 63,465 - 50,425
= 13,040

The school bus VMT is also assumed to be HDGV VMT.

The single-unit truck VMT is also divided between the truck categories using estimated nationwide registrations. After subtracting the HDGV registrations already apportioned to combination trucks and school buses, the truck registrations are:

Vehicle Types	Estimated Registrations	Percentage of Total Registrations
LDGT1	12,832,570	.5705
LDGT2	5,677,442	.2524
LDDT	40,958	.0018
HDGV	3,942,478	.1753
	22,493,448	

Apportioning the single-unit truck VMT to these categories by registration gives:

	Single Unit Truck VMT	Combinations' VMT	Buses' VMT	Total VMT
LDGT1	151,753			151,753
LDGT2	67,138			67,138
LDDT	479			479
HDGV	46,630	13,040	2,950	62,620
HDDV		50,425	2,957	53,382
				335,372

Estimated nationwide VMT for all vehicle types is shown in Table 6-3.

TABLE 6-3

VEHICLE MILES TRAVELED BY VEHICLE TYPE
NATIONWIDE AVERAGE ESTIMATES

(Rural and Urban)

Vehicle Types	Estimated Nationwide VMT ($\times 10^6$)	VMT Fractions
LDGV	1,116,180	.7559
LDDV	2,469	.0017
LDGT1	151,753	.1028
LDGT2	67,138	.0455
LDDT	479	.0003
HDGV	62,620	.0424
HDDV	53,382	.0362
MC	22,566	.0153
TOTAL	1,476,587	

TABLE 6-4

VMT FRACTIONS CALCULATED FROM VEHICLE MILES PER DAY AND NATIONAL REGISTRATION ESTIMATES

Vehicle Type	(A) Vehicle Miles Per Day (From Table 5-1)	(B) Estimated National Registrations ($x10^3$) (From Sec. 3)	(A x B) National VMT Per Day ($x10^3$)	VMT Fractions
LDGV	31.1	102,711.8	3,194,337	.7777
LDDV	31.1	227.2	7,066	.0017
LDGT1	26.3	12,832.6	337,497	.0822
LDGT2	33.8	5,677.4	191,896	.0467
LDDT	29.8	41.0	1,222	.0003
HDGV	36.7	4,654.5	170,820	.0416
HDDV	138.1	1,043.8	144,149	.0351
MC	8.3	7,305.0	60,632	.0148
			4,107,619	

An alternative method for estimating fractional vehicle miles traveled by vehicle type is to use the estimated nationwide registrations from Section 3 of this report and the average miles/day estimates from Section 5 to estimate VMT by vehicle type. The VMT estimates by vehicle type and the resulting VMT fractions calculated using this method are shown in Table 6-4.

The estimated national registrations in Table 6-4 are as determined using sales data and scrappage rates for each vehicle type. If the MOBILE2 methodology for estimating LDGV, LDDV, LDGT1, and LDDT registrations is used, the VMT fractions may be somewhat different. For example, Tables 3-7 and 3-10 can be compared to note the difference in the two methods for estimating LDDT registrations. In 1978, though, there were so few LDDV's and LDDT's in the vehicle fleet that the differences in using the different registration estimates for calculating VMT fractions would be negligible.

7. FRACTION OF VEHICLES WITH AIR CONDITIONING

National estimates of the fraction of vehicles with air conditioning by model year can be taken directly from Section 9 of Techniques for Estimating MOBILE2 Variables. They are presented in Tables 7-1 and 7-2.

TABLE 7-1

PERCENTAGE OF LIGHT-DUTY VEHICLES WITH FACTORY INSTALLED AIR CONDITIONING BY MODEL YEAR

NATIONAL AVERAGES

Model Year	U.S. Cars* % with AC	U.S. Cars** % of LDV Sales	Imports* % with AC	Imports** % of LDV Sales	Total+ Fleet % with AC
1978	80.8%	83%	30.7%	17%	72%
1977	81.7	81	27.1	19	71
1976	74.0	85	21.3	15	66
1975	72.6	82	19.3	18	63
1974	67.9	84		16	57
1973	72.6	85		15	62
1972	67.5	85		15	57
1971	63.4	85		15	54
1970	60.1	85		15	51
1969	55.3	89		11	49
1968	44.3	89		11	39
1967	38.0	91		9	35
1966	29.3	93		7	27
1965	23.3	94		6	22
1964	17.9	94		6	17
1963	14.1	95		5	13
1962	11.3	95		5	11
1961	8.1	94		6	8
1960	6.9	93		7	6
1959	6.2	90		10	6

* Source: Ward's Automotive Yearbook

** Source: McNutt, Dulla, and Lax, 1979

+ Data on the percentage of imports with AC for pre-1975 model years was not reported in Ward's Automotive Yearbook. The total fleet AC percentage for pre-1975 LDV's was calculated assuming no imports with AC.

TABLE 7-2

LIGHT-DUTY TRUCKS WITH FACTORY INSTALLED AIR CONDITIONING
BY MODEL YEAR

NATIONAL AVERAGES

Model Year	U.S. Light Trucks* % with AC	U.S. LDT's** % of Sales	Imports* % with AC	Imports** % of Sales	Total Fleet % with AC
1978	41.2%	93.4%	12.5%	6.6%	39%
1977	53.2	96.4	10.5	3.6	52
1976	33.3	94.1	2.1	5.9	32
1975	30.6	88.5		11.5	27
1974	29.3	91.6		8.4	27
1973		97.3		2.7	
1972		92.5		7.5	
1971		94.6		5.4	
1970		95.2		4.8	

* Source: Ward's Automotive Yearbook

** Source: McNutt, Dulla, and Lax, 1979

8. AMBIENT CONDITIONS

Table 8-1 gives monthly mean temperatures (dry bulb) for the continental United States based on ten years of observations. The corresponding monthly mean relative humidities have been further averaged over all hours of the day for purposes of this presentation. The humidity factor H (given in grains of water vapor per pound of dry air) was computed using the methodology in Section 4.2 of Techniques for Estimating MOBILE2 Variables. These are reported to the nearest whole number. The mean dry bulb temperature and relative humidity were used to infer corresponding wet bulb temperatures using standard psychrometric tables. No correction for ambient pressure variation was made. However, given the lack of sensitivity and resolution in a nationwide scale analysis of temperature, such a correction would be superfluous.

The values in Table 8-1 can be used to estimate the frequency of air conditioning usage in light-duty vehicles and light-duty trucks. Average monthly dry and wet bulb temperatures can be used in the discomfort index (DI) equation presented in Section 13 of the Techniques report to estimate the percentage of air conditioners in use nationwide for each month. It is strongly recommended that values specific to local means for the time period of analysis be used in the DI equation whenever possible.

TABLE 8-1

AMBIENT CONDITIONS LIKELY TO AFFECT VEHICLE AIR CONDITIONING USAGE

WET BULB TEMPERATURES CORRESPONDING TO MONTHLY
MEAN DRY BULB TEMPERATURES AND MEAN RELATIVE HUMIDITIES
FOR THE UNITED STATES

	Mean Dry Bulb (°F)*	Mean Reative Humidity (%)*	H(grains of water vapor/pound of dry air)**	Mean Wet Bulb (°F)†	Disconfort Index	AC Usage
January	45	67	31	40	49	0
February	49	64	36	43	52	0
March	55	65	41	49	57	0
April	65	69	63	59	65	0
May	72	72	91	66	70	0
June	81	67	112	73	77	70%
July	85	62	121	75	79	90%
August	85	62	121	75	79	90%
September	78	71	99	71	75	50%
October	68	68	71	61	67	0
November	56	67	44	50	62	0
December	48	68	33	43	51	0

* Source: Climatography of the United States Series 82

** To the nearest whole number

† Source: Handbook of Chemistry and Physics

9. VMT PERCENTAGE IN HOT/COLD STARTS

The nationwide average estimates of the VMT percentage in the hot and cold start modes presented here are based on the simplified method presented in The Determination of Vehicular Cold and Hot Operating Fractions for Estimating Highway Emission (Ellis, Camp, and Treadway, 1978). The Simplified Method is based on empirical relationships between cold and hot operating fractions and the average trip length of all auto driver trips with origins and destinations within an urban area.

Table 9-1 can be used to estimate cold and hot start VMT percentages by hour of the day for average trip lengths between 10 and 25 minutes. If estimates are needed for more than one hour, the cold and hot start VMT percentages for those hours can be averaged. If possible, it is probably appropriate to weight the cold and hot start percentages by the percentage of VMT during that hour to determine a weighted average.

Table 9-1 was derived using urban transportation planning data from six study areas in Alabama and from the Eastern Massachusetts Regional Planning Project (EMRPP) which includes Boston. The six study areas in Alabama range in population from 71,000 to 587,000 persons. All data in Table 9-1 apply to urban transportation planning study areas as a whole, and not exclusively to central business districts or any other areas of a city.

According to the NPTS, the average automobile trip length is 8.9 miles. Therefore, the columns for an average trip length of 20 minutes can be used for nationwide estimates of cold and hot starts if an average speed of 26.7 miles per hour is reasonable. The average speed of a light-duty vehicle or light-duty truck trip is based on the percentage of urban vs.

TABLE 9-1

PERCENTAGE OF VMT IN COLD AND HOT START MODES

NATIONAL AVERAGES

Hour Begin.	ATL = 10 Min.			ATL = 15 Min.			ATL = 20 Min.			ATL = 25 Min.		
	Non-Catalytic	Catalytic		Non-Catalytic	Catalytic		Non-Catalytic	Catalytic		Non-Catalytic	Catalytic	
	Cold	Cold	Hot	Cold	Cold	Hot	Cold	Cold	Hot	Cold	Cold	Hot
AM 1	47.5	58.0	10.0	28.7	36.4	7.0	15.6	24.2	3.7	8.2	17.5	3.7
2	49.6	57.6	10.0	29.8	35.4	7.0	17.4	21.9	6.0	16.0	18.8	6.0
3	57.3	61.1	8.5	27.3	29.5	8.0	18.7	21.0	7.2	16.2	19.5	6.7
4	59.5	61.7	7.0	33.3	34.8	7.0	19.6	21.0	7.0	17.0	18.0	7.0
5	63.7	65.6	7.0	31.5	31.7	7.0	20.0	20.0	7.0	18.0	18.0	7.0
6	61.2	62.0	8.0	32.1	32.8	8.0	20.0	20.2	8.0	17.0	17.0	8.0
7	56.3	59.7	10.0	29.6	31.9	10.0	18.0	18.3	10.0	16.2	16.2	10.0
8	45.5	51.8	22.0	22.7	27.3	17.4	14.2	15.2	13.5	13.6	14.4	10.0
9	34.2	47.4	29.0	17.0	24.1	19.5	9.3	13.1	14.3	8.3	11.2	12.0
10	27.7	41.0	36.1	14.3	24.2	23.7	7.1	13.3	16.0	5.6	10.0	13.0
11	17.6	37.0	36.8	10.0	22.6	23.8	5.7	13.2	16.1	4.6	10.0	12.3
12	18.8	35.3	37.7	10.8	21.5	24.5	6.0	13.3	15.2	5.0	10.0	12.5
PM 1	18.6	39.4	38.8	11.2	24.6	22.7	5.8	12.8	14.0	4.8	10.0	13.0
2	22.2	39.3	31.4	13.6	24.5	22.0	6.2	12.3	16.0	4.7	10.4	12.0
3	29.2	42.3	26.7	17.9	25.2	19.4	10.4	14.3	14.4	6.8	12.0	12.0
4	29.0	41.3	29.4	17.2	24.7	19.6	11.3	16.5	21.0	10.0	14.0	9.7
5	28.3	41.7	28.7	16.9	24.7	19.0	11.9	16.3	11.4	10.2	13.8	8.4
6	19.5	40.1	31.8	12.1	24.9	21.0	8.0	14.2	14.6	5.0	12.0	11.3
7	17.3	42.8	31.0	10.7	26.2	21.0	5.0	14.0	14.6	3.0	11.0	12.0
8	14.0	45.0	28.4	9.5	27.5	19.7	3.5	13.7	14.6	2.0	10.5	12.4
9	15.8	47.6	27.6	10.5	30.7	15.2	3.7	17.6	10.0	2.7	13.2	10.0
10	30.4	53.0	17.0	19.5	32.7	11.1	7.5	19.4	8.3	4.6	15.0	7.0
11	43.0	57.7	14.1	24.6	33.5	9.7	11.3	19.3	7.9	7.5	16.0	8.0
MIDN	44.7	56.2	13.0	27.3	35.0	10.2	15.0	20.0	7.6	11.8	17.5	5.0

ATL = Average trip length of all internal auto driver trips.

Source: Ellis, Camps and Treadway, 1978.

rural driving. Thus, the information in Section 11 of this report can be used to determine an average trip speed. This average speed can then be used to derive an average trip length in minutes in order that Table 9-1 can be used.

10. AVERAGE TRIPS PER DAY WITH EXTRA LOAD AND TOWING TRAILERS

10.1 EXTRA LOAD

The calculations in Table 10-1 show .43 daily trips or 11.2 percent of all trips by light-duty vehicles involve carrying a heavy load (four or more occupants). While vacation trips account for a small fraction of total LDV VMT, they account for a relatively large share of the average daily trips with extra load.

Since no specific techniques for estimating the percentage of light duty truck trips with an extra load were presented in Techniques for Estimating MOBILE2 Variables, no nationwide estimate was made for this vehicle category.

10.2 TRAILER TOWING

The nationwide average percentage of light-duty vehicles towing trailers can be estimated using the methodology presented in Section 10.3.2, of the Techniques report. According to that section, 2.4 percent of all light-duty vehicles have trailers available. Table 10-1 of that section shows that vacation trips are 0.132 percent of total trips in all places. Therefore, multiplying the percentage of light-duty vehicles with trailers available by the percentage of all trips that are vacation trips yields a nationwide estimate of 0.0032 percent of LDV trips towing trailers.

Similarly for light-duty trucks, the nationwide estimate for the percentage of trips with trailers is 0.0054 percent.

TABLE 10-1

NATIONAL AVERAGE DAILY LDV TRIPS WITH 4 OR MORE OCCUPANTS PER HOUSEHOLD FOR ALL PLACES

	% of Trips With 4 or More Occupants	Daily Trips per Household per Purpose	Number of Daily Trips with 4 or More Occupants
Earning a Living	3.3	1.4	.046
Family Business	10.1	1.2	.121
Educational, Civic & Religious	22.6	0.4	.090
Vacation	21.3	0.8	.170
Total		3.8	.427

11. NATIONAL AVERAGE SPEEDS

National average speeds are estimated using speed data from the "CUTS Manual" (DeLeuw, Cather and Co., 1979), FHWA's Highway Statistics (U.S. DOT, 1978), and travel fractions by road type and vehicle type from MVMA (1979). Since vehicles operate at significantly different speeds, depending on road type, it is necessary to weight speeds by the fraction of time a particular vehicle type spends on each type of roadway. For example, light-duty vehicles accumulate a larger share of total VMT on urban streets and roadways than do heavy-duty diesel trucks; similarly, heavy trucks accumulate a far greater fraction of total miles on rural interstates than do LDV's.

The estimated average speeds are shown in Tables 11-1 through 11-4. Not surprisingly, heavy trucks average much higher speeds than LDV's and light trucks. The average 37.9 mph for LDV's is substantially higher than the 19.6 mph used in MOBILE1. The explanation of this discrepancy is that MOBILE1 speed data are based on urban driving (Federal Test Procedure). The MOBILE2 estimate accounts for nationwide VMT accumulation which presumably has a much larger share of cruise speed driving on both interstate and state highways.

Highway speeds were not broken down by vehicle type by FHWA. Since the State of Michigan provides highway speeds by roadway type for two categories of vehicles (passenger and commercial) it is possible to use Michigan data to weight the national average speeds and disaggregate passenger and commercial vehicle speeds. Table 11-5 shows these calculations. It was assumed that all light-duty vehicles and light trucks are passenger vehicles; heavy trucks and buses were assumed to be commercial vehicles. The ratio of national to Michigan speed for all vehicles for

TABLE 11-1

NATIONAL AVERAGE SPEEDS
FOR LIGHT-DUTY VEHICLES

Roadway Type	Speed	Fraction of all* LDV Travel
Interstate rural	59.8	.073
Other main rural	55.8	.274
Local rural	25.0**	.069
Interstate urban	56.8	.106
Other urban+	22.0	.478
CBD	15.0	
Fringe	22.0	
Residential	26.0	
Outlying Business District	18.0	
Weighted average speed	37.9	

* MVMA, 1979.

** Assumed, based on state law maximum speeds in incorporated areas.

+ Assumes 75 percent volume-to-capacity ratio.

TABLE 11-2

NATIONAL AVERAGE SPEEDS
FOR ALL LIGHT-DUTY TRUCKS
(LDGT1, LDGT2, LDDT)

Roadway Type	Speed	Fraction of all* LDT Travel
Interstate rural	59.8	.075
Other main rural	55.8	.356
Local rural	25.0**	.037
Interstate urban	56.8	.058
Other urban	22.0+	.474
CBD	15.0	
Fringe	22.0	
Residential	26.0	
Outlying business district	18.0	
Weighted average speed	39.0	

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* MVMA, 1979.

** Assumed, based on state law maximum speeds in incorporated areas.

+ Assumes 75 percent volume-to-capacity ratio.

TABLE 11-3

NATIONAL AVERAGE SPEEDS FOR
HEAVY-DUTY GASOLINE VEHICLES

Roadway Type	Speed*	Fraction of all** HDGV Travel
Interstate rural	60.5	.130
Other main rural	53.9	.379
Local rural	25.0+	.042
Interstate urban	54.1	.066
Other urban	22.0++	.383
CBD	15.0	
Fringe	22.0	
Residential	26.0	
Outlying business district	18.0	
Weighted average speed	41.3	

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* Commercial vehicle speeds used since school bus VMT is only 5 percent of total HDGV VMT.

** MVMA, 1979.

\+ Assumed, based on state law maximum speeds in incorporated areas.

++ Assumes 75 percent volume-to-capacity ratio.

TABLE 11-4

NATIONAL AVERAGE SPEEDS FOR
HEAVY-DUTY DIESEL VEHICLES

Roadway Type	Truck Speeds	Truck Travel* Fraction	Bus Speeds	Bus Travel* Fraction
Interstate Rural	60.5	.342	60.5	.100
Other Main Rural	53.9	.452	53.9	.270
Local Rural	25.0**	.016	25.0**	.031
Interstate Urban	54.1	.093	30.0	.106
Other Urban	22.0+	.097	11.0+	.493
CBD	15.0		5.0	
Fringe	22.0		11.0	
Residential	26.0		11.0	
Outlying Bus. Dist.	18.0		15.0	
Weighted Average Speeds by Vehicle Type	52.6 mph		30.0 mph	
Weighted Average Speed for all HDDV++	51.6 mph			

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* MVMA, 1979.

** Assumed, based on state law maximum speeds in incorporated areas.

\+ Assumes 75 percent volume-to-capacity ratio.

++ Weighted by relative shares of total diesel VMT:
Truck fraction = .956 (calculated from Section 6)
Bus fraction = .0442 (calculated from Section 6)
VMT weighted average speed = (52.6 x .956) + (30.0 x .0442)

TABLE 11-5

CALCULATIONS OF NATIONAL SPEEDS FOR
THE DIFFERENT VEHICLE TYPES

A. Calculations of Average Speed Values for Light Duty Vehicles

1. Interstate Rural

National Average Speed on Interstate Rural 58.8 mph

Michigan Average Speed on Interstate Rural 57.8 mph

Ratio (Correction Factor) = 58.8/57.8
= 1.017

Michigan Average Passenger Car
Speed on Interstate Rural = 58.8

National Average Passenger Car
Speed on Interstate Rural = 59.8

2. Other Main Rural

Other Main Rural is defined as the average of Multi-lane Divided and 2-lane Rural

Average of Multi-lane Divided and 2-lane Rural for
National Value = $\frac{56.5 + 54.9}{2}$

= 55.7

National Other Main Rural = 55.7

Michigan Other Main Rural = $\frac{57.6 + 54.7}{2}$

= 56.15

Correction Factor = 55.7/56.15

= .992

Michigan Average Passenger Car
Speed on Other Main Rural = $\frac{57.9 + 54.5}{2}$

= 56.2

TABLE 11-5 (Cont'd)

National Average Passenger Car
Speed on Other Main Rural = 56.2 x .992

= 55.75

3. Interstate Urban

National Average Speed on Interstate Urban = 56.7

Michigan Average Speed on Interstate Urban = 56.4

Correction Factor 56.7/56.4

= 1.0053

Michigan Average Passenger Car Speed on
Interstate Urban = 56.5

National Interstate Urban = 56.5 x 1.0053

= 56.8

B. Calculations of Average Speed Values for Light Trucks

These are the same as the speed values for light duty vehicles

C. Weighted Average Speed for LDV

Formula Weighted Average Speed = $\frac{\text{(Speed)(fraction LDV Travel)}}{n}$

D. Calculations of Speeds of Heavy Duty Vehicles

These are the same for heavy duty trucks and buses

TABLE 11-5 (Cont'd)

Class	Michigan Average Commercial Vehicle Speed	Correction Factor	National Commercial Average Speed
Interstate Rural	59.5	1.017	60.5
Other Main Rural (Multi-Lane Divided 2 Lane Rural)	$\frac{55.7 + 52.9}{2}$ = 54.3	.992	53.9
Interstate Urban	53.8	1.0053	54.1

The Weighted Average Speeds for both heavy duty trucks and commercial buses was worked out as follows:

$$\frac{\sum^{n} (\text{speed})(\text{fraction LDV travel})}{n}$$

each roadway type was computed and used as a correction factor. Then, for example, the Michigan average passenger car speed, for a particular roadway type, was multiplied by the appropriate correction factor to estimate national average passenger car speed. The same procedure was used for commercial vehicles.

The fractions of travel by vehicle type were obtained directly from MVMA in most cases. Since the heavy-duty gas truck category did not match MVMA's categories, the HDGV travel fractions were weighted according to the procedure shown in Table 11-6. This weighting of MVMA categories is consistent with that used in Section 6 of this document.

TABLE 11-6

CALCULATION OF FRACTION OF HDGV VMT BY ROADWAY TYPE

HDGV VMT =	62,620	100.0%
single unit	46,630	74.5%
combination	13,040	20.8%
school buses	2,950	4.7%

VMT FOR MVMA VEHICLE TYPE BY ROAD TYPE

	Single Unit	Combination	School Bus
Interstate Rural	.075	.342	.056
Other Main Rural	.356	.452	.419
Local Rural	.037	.016	.217
Interstate Urban	.058	.093	.070
Other Urban	.473	.097	.238

HDGV WEIGHTED FRACTION OF VMT BY ROAD TYPE

	Single Unit	Combination	School Bus	Total
Interstate Rural	.056	.071	.003	.130
Other Main Rural	.265	.094	.020	.379
Local Rural	.028	.004	.010	.042
Interstate Urban	.044	.019	.003	.066
Other Urban	.352	.020	.011	.383
	.745	.208	.047	1.000

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